

PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Electrolyte or Electroless Plating Process

We, INTERNATIONAL BUSINESS MACHINES CORPORATION, a Corporation organized and existing under the laws of the State of New York in the United States of America, of 5 Armonk, New York 10504, United States of America (assignees of JEAN PAUL LENOBLE, BRUCE PAUL PIGGIN, ANTON MAX SETZER and ERIC VAUGHAN), do hereby declare the invention for which we pray that a patent 10 may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to electrolytic or 15 electroless deposition on a workpiece.

According to one aspect of the invention there is provided a method of electrolytic or electroless deposition on a workpiece using an insulating masking means 20 defining one or more openings extending from an otherwise impermeable engagement surface of the insulating masking means, and a porous support member, including placing said engagement surface 25 from which said one or more openings extend against the workpiece so that the workpiece seals one end of each of said one or more openings, the opposite end of each of said one or more openings being covered 30 by said support member which backs and exerts pressure against said masking means, and effecting deposition by an electrolytic or electroless process selectively on the workpiece on the area or areas thereof registering with said one or more openings 35 using a deposition solution present in said one or more openings and in said support member.

According to another aspect of the invention there is provided a method of 40 electrolytic or electroless deposition on a workpiece using an insulating masking means defining one or more openings ex-

tending from an otherwise impermeable engagement surface of the insulating masking 45 means, and a porous support member, including bringing said engagement surface from which said one or more openings extend into engagement with the workpiece so that the workpiece seals one end of at least 50 said one or more openings, the opposite end of said at least one opening being covered by said support member which backs and exerts pressure against said masking means, and effecting deposition by 55 an electrolytic or electroless process selectively on the workpiece on the area or areas thereof registering with the opening or openings sealed by the workpiece using a deposition solution present in said support 60 member and in the opening or openings sealed by the workpiece.

The insulating masking means in effect acts as a mould for the material being deposited on the workpiece. 65

The invention will be further explained by way of example with reference to the accompanying diagrammatic drawings in which:—

Fig. 1 is an enlarged cross-sectional detail of two laminated components being used for carrying out the invention according to a first method; 70

Fig. 2 is a horizontal cross-section showing how the components of Fig. 1 can be 75 pressed together;

Fig. 3a is a vertical cross-section of another form of apparatus for carrying out the invention according to another method;

Fig. 3b is a perspective view of part of 80 the apparatus shown in Fig. 3a;

Figs. 4a to 4e illustrate the cross-sections of a number of conducting elements which can be deposited according to the invention; 85

Fig. 5 is a cross-sectional view of a

composite "printed" circuit which can be formed by a method in accordance with the invention;

Fig. 6 is a partly sectioned plan view of another form of apparatus for carrying out the invention according to a further method;

Fig. 7 is a horizontal cross-section of another form of apparatus for carrying out the invention according to a further method;

Fig. 8 is a view taken on the line 9-9 of Fig. 7;

Fig. 9 is a cross-section taken on the line 10-10 of Fig. 7; and

Fig. 10 is a vertical cross-section of another form of apparatus for carrying out the invention.

Fig. 1 shows a laminated anode component 14 and a laminated cathode or workpiece component 15. The component 14 comprises a porous metal plate 16 to which an insulating sheet-like masking means 17 is bonded, and the masking means 17 defines an opening 18 extending from an otherwise impermeable engagement surface 19 of the masking means. A recess 20 is formed in the plate 16 and communicates with the opening 18. The component 15 comprises an insulating substrate 22 on which a thin layer 23 of metal; e.g. copper, is deposited by a suitable technique such as vapour deposition, or electroless deposition.

The components 14, 15 are immersed in an electrolyte bath (not shown in Fig. 1) and are pressed together, with the engagement surface 19 abutting the layer 23, so that electrolyte is trapped in the opening 18 and in the recess 20, and so that the layer 23 seals the lower end of the opening 18 as seen in Fig. 1, the electrolyte being forced out from all areas between the engagement surface 19 and the layer 23.

Electrical connections shown only diagrammatically in Fig. 1 are made to the plate 16 and to the layer 23, and current is passed from the plate 16 which constitutes a soluble anode, via the electrolyte in the opening 18, recess 20 and pores (not shown) of the plate 16 to the layer 23 which is the cathode. Thus metal from the electrolyte and dissolved from the anode is deposited on the layer 23 as shown at 25, the walls 26 of the opening 18 in the insulating masking means in effect acting as a mould for material being deposited on the workpiece, provided that the engagement surface 19 makes good sealing contact with the layer 23 round the periphery of the opening 18.

The anode component 14 may be made for example by applying an insulating photosensitive resist coating to a copper plate, exposing the coating to light in predetermined areas, developing the coating so

that parts thereof which have not been light-hardened are removed, and etching the copper plate through the openings formed by the development in the coating to produce recesses such as 20. The size and shape of the opening 18 where it opens into the engagement surface 19, is determined accurately by the exposure step. However, from the engagement surface, the walls 26 of the opening 18 incline inwardly the effect being more pronounced with thicker layers of photosensitive resist, due to the nature of the photosensitive resist and the development process, so that the size and shape of the opening 18 adjacent the plate 16 cannot readily be predicted with accuracy. This method is therefore most suitable where accuracy of the base dimensions of the deposited metal 25 is a primary consideration.

The two components 14, 15 may be pressed together by apparatus shown in horizontal cross-section in Fig. 2. Electrolyte is placed in the space 30, and fluid under pressure; e.g. water or air, is connected to the two pipes 31, 32 so as to extend two rubber sheets 33, 34 which are sealed to side walls 35, 36 respectively, towards one another. The components 14, 15 are initially placed between the sheets 33, 34 in the electrolyte spaced from one another so that the electrolyte fills the recesses 20, and then the fluid under pressure is connected to the pipes 31, 32.

An acid copper sulphate solution can be used as the electrolyte, and the current density and plating time can be readily calculated having regard in particular to the required dimensions of the deposited metal. The current density should be less than that at which gas bubbles occur in the electrolyte. The choice of electrolyte depends *inter alia* on the metal to be plated and the kind of deposit to be formed; e.g. bright copper or dull copper, and on whether a constant concentration of metal ions can be maintained in the electrolyte during deposition, using a soluble anode.

When the plating has been completed, the current is turned off, the fluid pressure to the pipes 31, 32 is disconnected, and the two components 14, 15 are withdrawn from the electrolyte and separated perpendicularly to one another and rinsed in water. The component 15 is then subjected to a light etching process just sufficient to remove the parts of the layer 23 not covered by the deposited metal 25.

An important advantage of the method is that the anode component 14 can be used many times on different workpiece components 15 without requiring a new masking means 17.

As regards the insulating masking means, a photosensitive sheet or layer is most suitable.

able for complicated patterns of openings. Examples of photosensitive resist which can be used are Kodak (Trade Mark) Resist KPR or KOR or PCR, or polyvinyl alcohol. Alternatively, photopolymerizable sheets or layers can be used such as photosensitive nylon.

Instead of using photosensitive material for the insulating masking means, non-photosensitive insulating material can be used. For example the insulating masking means may be plastics sheeting in which openings are formed, e.g. by punching while the sheeting is separate from the anode plate (16 in Fig. 1). Alternatively, the insulating masking means may comprise plastics material which is coated on the anode plate and then scribed mechanically or with an electron or laser beam.

The apparatus shown in Fig. 3a can be used for plating both sides of a workpiece simultaneously and comprises a tank 40 to which a lid 41 is secured by bolts 42. The lid has an opening 43 bounded by a downwardly extending flange 44, and a strip metal frame 45 (see Fig. 3b) is secured to the flange, and a flexible impermeable bag 46 made for example of rubber or a synthetic plastics material and dimensioned larger than the frame 45 is fitted over the frame and fastened (by means not shown) in sealing relationship to the flange 44. Thus the tank 40, the lid 41 and the bag 46 define a sealed compartment 47.

Ultrasonic transducers 48, 49 and a thermostatically controlled heater 50 are mounted on the walls of the tank 40, and a pipe 52 is connected to the lid and leads through to the compartment 47. The pipe 52 is connected to a pressure gauge 53, and to inlet and outlet pipes 54 and 55 respectively, each of which is fitted with a shut-off valve. An upstanding flange 57, which is secured to the lid, defines an overflow compartment 58 which communicates with the interior of the bag 46.

In use, the tank 40 is filled with liquid, e.g. water, and the lid 41 is bolted in place. Electrolyte is then poured into the bag 46, almost to the level of the flange 44, and a loose assembly comprising a cathode component 59 disposed between two anode components 60, 61 is placed in the electrolyte in the bag. The components are maintained in registering relationship by means of insulating guide pins (not shown), e.g. provided on the cathode component and engaging holes in the anode components, the guide pins permitting the components to separate from one another a short distance. The cathode component comprises an insulating substrate which has been metallised on both sides, and each anode component is formed as explained with reference to Fig. 1. Electrical connections

to the components are shown diagrammatically in Fig. 3a.

The ultrasonic transducers 48, 49 are operated at 40 Kcps to drive out any air bubbles in the electrolyte between the 70 components, and the inlet pipe 54 is connected by the shut-off valve to the component 47 to pressurise it and to force the walls of the bag 46 inwardly against the anode components. The inlet pipe 54 75 may for example be connected to a water mains service pipe. Thus the anode components are pressed tightly against the metallised surfaces of the cathode component by the pressure in the compartment 80 47, and electrolyte displaced from the bag 46 enters the overflow compartment 58. The heater 50 maintains the temperature of the electrolyte at a suitable level, and the current to the components 59, 60, 61 is 85 switched on for a predetermined period. Finally, the outlet pipe 55 is connected to the compartment 47 by its shut-off valve in place of the inlet pipe 54, and the electrolyte flows from the overflow compartment 90 back into the bag 46 to release the components 59, 60, 61. The components are withdrawn together, and separated from one another perpendicularly prior to washing the cathode component with water, and 95 lightly etching it.

In one experiment, the bag 46 was filled with electrolyte, one litre of which had the following composition:—

Copper sulphate	200 grams	100
Sulphuric acid (Specific gravity 1.84)	31 cc.	
Potash alum	12 grams	
Distilled Water	balance	

An etchant comprising a saturated solution of sodium or potassium dichromate in distilled water containing 5 to 10% sulphuric acid of specific gravity 1.84 can be used to remove the initial copper metallisation where it had not been covered by electrolytically deposited copper. Apart from its etching function the acidified dichromate solution also serves to clean and render passive the electrolytically deposited copper. Ferric chloride etching solution can be used instead of the dichromate solution. 115

In order to prevent copper being electrolytically deposited on the cathode component in areas outside the boundaries defined by the opening in the masking means (see reference 17 of Fig. 1), good sealing contact must be established between the masking means and the cathode component. Such contact depends in the case of the components illustrated in Fig. 3a on the flatness of the co-operating interfaces, and the pressure with which they are forced together. Results are generally improved if the cathode component 59 and 120 130

the masking means are resiliently compressible to a limited degree, rather than rigid. It should be noted that the adhesion of the copper metallisation to the cathode component 59 should be sufficient to enable the masking means to be separated from the cathode component after the electrolytic deposition process without removing the metallisation and the electrolytically deposited copper.

If desired, conducting elements of varying section can be deposited on a cathode component by a method according to the invention, using a masking means with an opening therein shaped complementarily to the conducting element. A number of such conducting elements are shown in Fig. 4, all of which allow the masking means to be separated from the cathode component after the deposition has been completed. Fig. 4a shows a "T"-section conducting line, Fig. 4b shows an "L"-section conducting line, Fig. 4c shows a trapezoidal-section conducting line, Fig. 4d shows a land with a "pin", and Fig. 4e shows a conducting line of variable thickness.

Also, composite multi-layer "printed" circuits can be formed by a method in accordance with the invention. Fig. 5 shows such a composite circuit, the conducting elements numbered from 82 to 88 being formed on a cathode component 89 in a single deposition process using the apparatus of Fig. 3a. The conducting elements 82 to 85 may each be as shown in Fig. 4d, and the elements 82, 83 and 84, 85 form two capacitors. The reference 86 denotes a plated-through hole which connects conducting elements 87, 88 disposed on opposite sides of the cathode component 89.

After the elements 82 to 88 have been formed, and the cathode component has been lightly etched to remove the metallisation thereon on which metal has not been deposited electrolytically, the sample is made flat by filling the spaces between the elements 82 to 88 with an uncured resin 90, e.g. an epoxy resin, curing the resin, and grinding, polishing and cleaning the opposite surfaces of the sample so that the outer surfaces of the "pins" of the elements 82 to 88 are flush with the surfaces of the resin 90.

The opposite surfaces of the sample are then metallised, and the conducting elements 91 to 96 are formed by a further single deposition process similar to the previous one and also in accordance with the invention.

This technique for forming multi-layer circuits can be used for example to make "printed" circuit coils, or multi-plate capacitors.

Fig. 6 is a partly-sectioned plan view of another form of apparatus for carrying out

the invention according to another method. The apparatus comprises a tank 100, to one end of which is sealed a flexible bag 101 which can be inflated through a pipe 102. A permeable support grid 103 is secured to and extends across the tank 100. When the bag 101 is inflated, it presses a cathode component 104 against a mask 105 which is held in place by the grid 103.

The cathode component 104 may be the same as that shown at 15 in Fig. 1. The mask 105 comprises a support member 107 made of an open-celled porous synthetic plastic material, e.g. polyvinyl chloride, polythene or polystyrene, to which is bonded an insulating masking means 108. Porous materials other than porous synthetic plastic material may be used for the support member 107, e.g. porous sintered glass. The insulating masking means 108 is formed by bonding a sheet of photopolymerizable plastics material to the support member 107, and suitably exposing and developing the sheet. This procedure can be used for insulating masking means of any reasonable thickness, whereas when a photosensitive resist is used, the thickness should preferably not exceed 0.0003" to avoid the convergency of openings formed in resist layers of greater thickness. The photopolymerizable sheet can be bonded to the support member 107, e.g. by a bond produced by a suitable heat process where the plastics material is thermoplastic, or by a suitable solvent for the plastics material. In all cases, the openings formed in the insulating masking means must communicate with the support member 107 so that electrolyte placed in the tank can penetrate the openings by way of the porous support member.

An anode component 110 is also placed in the electrolyte in the tank but its position is not significant. Electrical connections to the anode and cathode components are shown diagrammatically. Relatively large pieces of matter resulting from decomposition of the anode can be prevented from reaching the support member 107 and clogging it by, for example, placing the anode in a permeable bag, or in a wad of glass fibre held in place by a synthetic plastic net.

It is believed that further details of the apparatus shown in Fig. 6 are unnecessary in view of the preceding description. Plating takes place through the support member 107. The bag 101 can be replaced by an arrangement for holding the cathode component 104 in contact with the mask 105 by suction; e.g. applied to the surface of the mask 105 opposite that co-operating with the cathode component. Such suction may also serve to cause electrolyte to circulate in the openings of the mask. A de-

tailed description of an arrangement for circulating electrolyte is given with reference to Figs. 7 to 9.

The apparatus of Fig. 6 may be used 5 to deposit a metal electrolytically on the cathode component, which metal is resistant to the etching fluid subsequently used to remove the metallisation on the cathode component on which the metal has not 10 been deposited electrolytically. For example, gold may be deposited electrolytically using a conventional gold plating bath, and the cathode component may then be etched using a ferric chloride solution 15 against which gold is highly resistant. Alternatively, a tin-lead alloy (60% tin, 40% lead) may be deposited electrolytically using a conventional fluoborate bath, and the cathode component may then be etched 20 using an ammonium persulphate solution which has a negligible effect on the tin-lead alloy.

Referring now to Figs. 7 to 9, the apparatus there shown comprises a tank 115 25 provided on two opposite walls with flexible bags 116, 117 which can be inflated through pipes 118, 119 respectively. When the bags are inflated in operation, they press together an anode component 120; a mask 30 121 comprising a porous support member 122 to which is bonded an insulating masking means 123; a cathode component 124; a mask 125 comprising a porous support member 126 to which is bonded an insulating 35 masking means 127; and an anode component 128. The masks 121, 125 may be formed generally as described for the mask 105 of Fig. 6, except that the porous support members 122, 126 are each provided 40 with an inlet passage 130 (Figs. 8 and 9) communicating with a plurality of parallel narrow channels 131 formed in the surface to which the respective insulating masking means 123 or 127 is secured. The open- 45 ings in the insulating masking means communicate with one or more of the channels 131, as indicated for the opening 132 in Fig. 9.

The cathode component 124 is metallised 50 on both sides, and electrical connections to the metallisation of the cathode component and to the anode components are shown diagrammatically in Fig. 9.

In operation electrolyte is pumped to 55 the inlet passage 130 of each mask, and drains into the tank 115. From there, the electrolyte is drawn through apparatus (not shown) comprising a filter, and means for replacing agents lost from the electrolyte 60 during deposition, before returning to the pump feeding each inlet passage 130. The apparatus is particularly useful for obtaining bright copper deposits on the cathode component 124, using an acid 65 copper sulphate solution as the electrolyte

with additional agents governing the "brightness" of the copper deposited. Such additional agents would be relatively quickly exhausted in "stagnant" electrolyte, but circulating the electrolyte enables more of the 70 additional agents to be added to the electrolyte during the deposition, so that their concentration in the electrolyte remains constant.

The electrolyte reaches the anode com- 75 ponents by way of the respective porous support member 122 or 126. If desired, further channels can be formed in the porous support members 122, 126 adjacent the anode components 120, 128 so that 80 electrolyte flows in contact with the anode components.

Another advantage of using a flowing electrolyte is that the current density can be increased to reduce the total plating 85 time required for depositing a given quantity of metal.

If desired, the suction side of the pump (not shown) can be connected to the two passages 130, and the tank 115 can be kept 90 filled with electrolyte to a level above that of the bottom ends of the channels 131. With this arrangement, the suction would assist to some extent in keeping each mask 121, 125 pressed against the cathode 95 component 124.

A further possibility with the apparatus of Figs. 7 to 9, is to use inert insoluble anode components; e.g. of platinum or 100 graphite and to use several plating solutions in succession from which different metal ions can be deposited on the cathode component. In this way, for example, copper can first be deposited, and then gold on top of the copper. The plating 105 solutions, and a washing solution, would be kept in separate tanks, each of which could be connected to the pump (and the tank) by its own pipes and valves. Since in this case soluble anodes are not used, 110 the strength of the plating solutions will vary during deposition unless appropriate materials are progressively added in appropriate quantities.

The invention is applicable to electroless 115 plating as well as to electrolytic plating, and it is considered that the modifications required for the apparatus previously described will be apparent to those skilled in the art. For example, with the apparatus of 120 Figs. 7, 8 and 9, the anode components 126, 128 would be omitted, and the cathode component 124 would be metallised, but would consist of the substrate only. Assuming that copper is to be deposited on the 125 substrate (124), first the substrate is "sensitised" by dipping in stannous chloride solution and palladium chloride solution, and immediately after, it is washed in water, and placed between the masks 121, 125, 130

which are then inserted between the bags 116, 117. The bags are inflated to press the masks against the substrate, and a suitable electroless copper deposition solution is pumped to the inlet passage 130 of each mask. Electroless deposition takes place on all "sensitised" areas of the substrate not in contact with the insulating masking means 123, 127. Deposition takes place slowly, but there is no need to etch metallised copper on the substrate after deposition. Electroless deposition could also be carried out using the apparatus of Fig. 6, and in this case, the cathode component 104 would not be metallised, and the anode 110 would be omitted.

For both electrolytic and electroless plating, the porous support members 122, 126 of the apparatus of Figs. 7 to 9 can be provided without the grooves 131, but fitted with suitable sealing means to contain and direct the flow of working fluid so that it flows from one edge of each support member to the opposite edge. In fact this arrangement has been found preferable.

The apparatus shown in Fig. 10 can be used for mass production of plated circuits. It comprises a tank 135 containing electrolyte in the form of an acid copper sulphate solution. Spaced about the tank are four rollers 136, 137, 138 and 139 round which an endless belt 140 passes. The belt 140 co-acts with a cylinder 141 between the rollers 136, 137 to hold the cylinder on its axis when the belt is advanced by a motor 134 connected to the roller 137. Flexible strip material 142 in the form of an insulating substrate metallised with evaporated copper on the surface which faces the cylinder 141 passes from a feed roll 143 between the belt and the cylinder to a take-up roll 144. A roller 145 connected to the negative of a D.C. electric power supply contacts the metallised surface of the strip 142, and a copper anode 146 is immersed in the electrolyte and is connected to the positive of the D.C. power supply.

The cylinder 141 comprises a porous cylindrical support member 150 round which a cylindrical insulating masking means 151 is secured. The insulating masking means is provided with openings by any of the methods previously described, so that electrolyte can reach the metallised surface of the strip through the porous support member 150 and the openings in the insulating masking means 151.

The belt speed and current can be determined theoretically or experimentally. The plated strip material on the take-up roll 144 still requires to be lightly etched and washed. The strip material could of course be passed through an etching bath and a washing bath before it is wound on the

take-up roll.

The apparatus shown in Fig. 10 can be modified by arranging the belt 140 and its rollers 136 to 139 so that the belt does not pass round the tank as it travels from roller 137 to roller 136, e.g. by locating the rollers 138, 139 within the tank. This arrangement ensures that material does not crystallise on the belt as it returns from roller 137 to roller 136.

It is not an essential requirement of the invention that the engagement surface of the insulating masking means be planar: the engagement surface should be complementary in shape to the surface of the workpiece against which it is to be placed, apart from where the openings occur in the engagement surface. Thus metal can be deposited in accordance with the invention on workpieces having an irregular surface.

WHAT WE CLAIM IS:—

1. A method of electrolytic or electroless deposition on a workpiece using an insulating masking means defining one or more openings extending from an otherwise impermeable engagement surface of the insulating masking means, and a porous support member, including placing said engagement surface from which said one or more openings extend against the workpiece so that the workpiece seals one end of each of said one or more openings, the opposite end of each of said one or more openings being covered by said support member which backs and exerts pressure against said masking means, and effecting deposition by an electrolytic or electroless process selectively on the workpiece on the area or areas thereof registering with said one or more openings using a deposition solution present in said one or more openings and in said support member.

2. A method of electrolytic or electroless deposition on a workpiece using an insulating masking means defining one or more openings extending from an otherwise impermeable engagement surface of the insulating masking means, and a porous support member, including bringing said engagement surface from which said one or more openings extend into engagement with the workpiece so that the workpiece seals one end of at least one of said one or more openings, the opposite end of said at least one opening being covered by said support member which backs and exerts pressure against said masking means, and effecting deposition by an electrolytic or electroless process selectively on the workpiece on the area or areas thereof registering with the opening or openings sealed by the workpiece using a deposition solution present in said support member and in the opening or openings sealed by the workpiece.

3. A method as claimed in claim 1 or 2 including forming said insulating masking means by exposing one or more selected areas of one surface of a sheet or layer of photosensitive insulating material to suitable radiation, developing said sheet or layer to form said openings extending from said one surface, and using said one surface as said engagement surface.
4. A method as claimed in claim 3, including bonding said sheet or layer of photosensitive material, before it is exposed, to said support member, the support member supporting said sheet or layer during exposure and development thereof and during deposition on the workpiece, the development resulting in the formation of said openings which extend through the entire thickness of said sheet or layer and to the support member.
5. A method as claimed in claim 4 in which said support member is made of metal and serves as an anode in electrolytic deposition on the workpiece.
6. A method as claimed in claim 5, including etching said anode through said openings prior to the electrolytic deposition, to form recesses in the anode registering with said openings.
7. A method as claimed in any of claims 1 to 4 in which said support member is made of a synthetic plastic material.
8. A method as claimed in any one of the preceding claims in which said support member is adapted to direct a flow of liquid across the interface between the insulating masking means and the support member so that the liquid can enter the openings in the insulating masking means, the method including so directing a flow of electrolyte, or electroless deposition solution, and/or a washing or rinsing liquid.
9. A method as claimed in claim 8 in which said support member serves to direct a flow of electrolyte or electroless deposition solution, the method including re-circulating the electrolyte or electroless deposition solution through the support member while maintaining constant the concentration of the constituents in the electrolyte or the electroless deposition solution.
10. A method as claimed in claim 8 or 9 including directing a first liquid through the support member so that a first metal is deposited on the workpiece, and then directing a second liquid through the support member so that a second metal is deposited on the first metal on the workpiece.
11. A method as claimed in claim 7 as dependent on claim 2 in which said support member has a cylindrical form, and said insulating masking means extends round said support member.
12. A method as claimed in any one of claims 1 to 10, in which said insulating masking means is pressed against the workpiece during deposition by fluid pressure.
13. A method as claimed in any one of the preceding claims in which metal is deposited electrolytically or electrolessly on both sides of the workpiece simultaneously, each side of the workpiece being associated with a respective insulating masking means.
14. A method as claimed in any one of the preceding claims in which after deposition has been carried out on a surface of the workpiece, that surface is built up with insulating material to the level of the deposits thereon, and the method is repeated on the new surface of the workpiece using a different insulating masking means.
15. A method of electrolytic deposition on a workpiece, substantially as described with reference to Figs. 1 and 2 of the accompanying drawings.
16. A method of electrolytic deposition on a workpiece, substantially as described with reference to Figs. 3a and 3b of the accompanying drawings.
17. A method of electrolytic deposition on a workpiece, substantially as described with reference to Fig. 5 of the accompanying drawings.
18. A method of electrolytic or electroless deposition on a workpiece, substantially as described with reference to Fig. 6 of the accompanying drawings.
19. A method of electrolytic or electroless deposition on a workpiece, substantially as described with reference to Figs. 7, 8 and 9 of the accompanying drawings.
20. A method of electrolytic or electroless deposition, substantially as described with reference to Fig. 10 of the accompanying drawings.
21. A method of making a "printed" circuit including depositing metal electrolytically or electrolessly on a workpiece by a method as claimed in any one of the preceding claims.
22. A workpiece on which metal has been deposited electrolytically or electrolessly by a method as claimed in any one of the preceding claims.
23. A "printed" circuit having at least one conducting element deposited thereon electrolytically or electrolessly by a method as claimed in claim 21.
24. Electrolytic deposition apparatus substantially as described with reference to Figs. 1 and 2 of the accompanying drawings.
25. Electrolytic deposition apparatus substantially as described with reference to Figs. 3a and 3b of the accompanying drawings.
26. Electrolytic or electroless deposition apparatus substantially as described with reference to Fig. 6 of the accompanying drawings.
27. Electrolytic or electroless deposition

apparatus substantially as described with reference to Figs. 7, 8 and 9 of the accompanying drawings.

28. Electrolytic or electroless deposition
5 apparatus substantially as described with reference to Fig. 10 of the accompanying drawings.

29. A workpiece on which metal has been deposited using apparatus as claimed in any one of claims 24 to 28. 10

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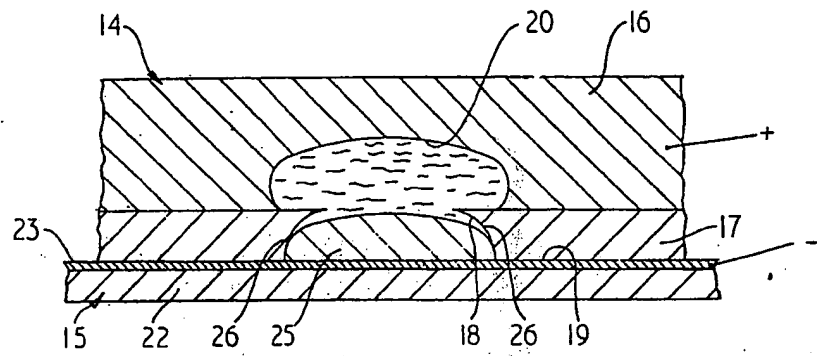


FIG. 1

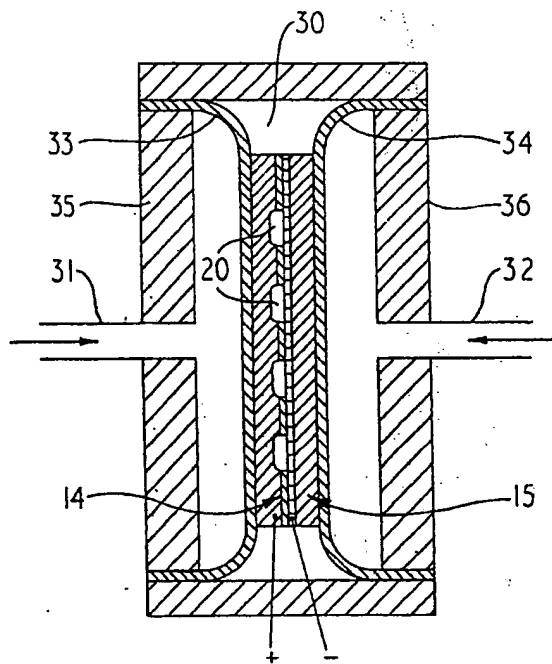
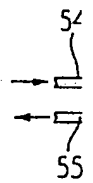


FIG. 2

1,098,182
4 SHEETS

COMPLETE SPECIFICATION

This drawing is a reproduction of
the Original on a reduced scale.
SHEETS 1 & 2

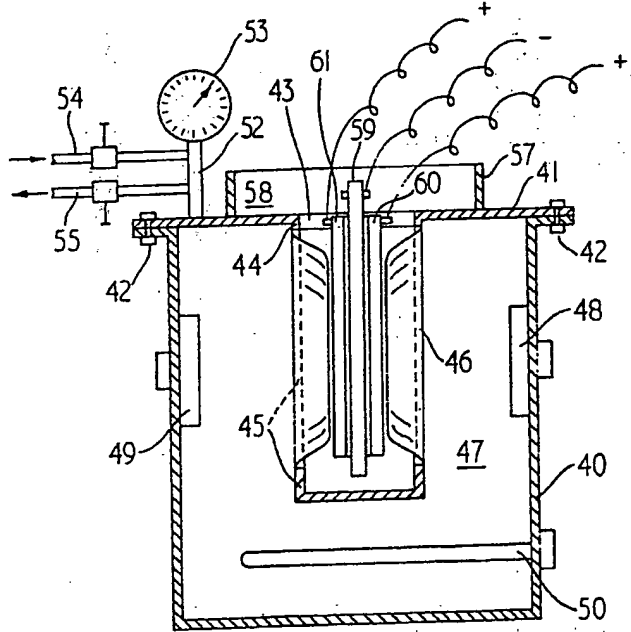


FIG. 3a

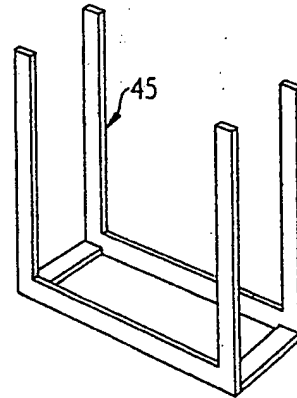
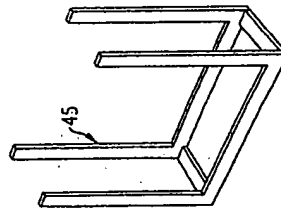
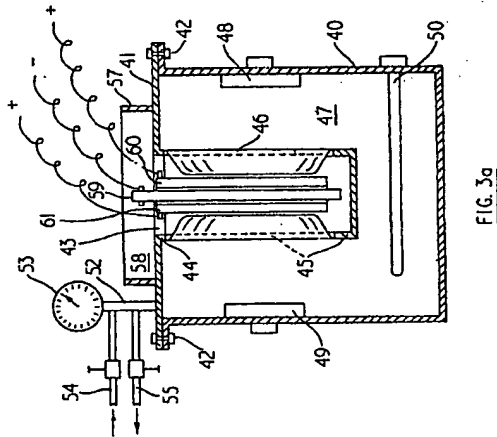
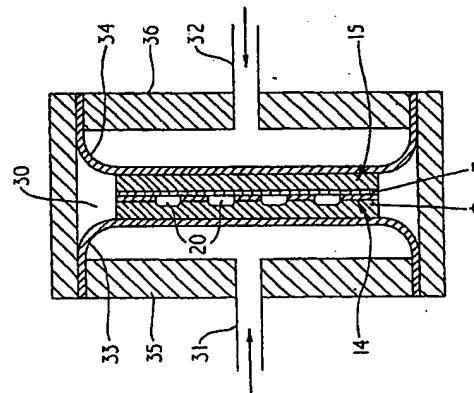
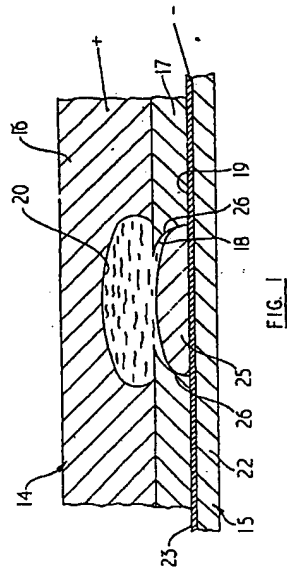


FIG. 3b

1,098,182 COMPLETE SPECIFICATION
4 SHEETS This drawing is a reproduction of
the Original on a reduced scale.
SHEETS 1 & 2



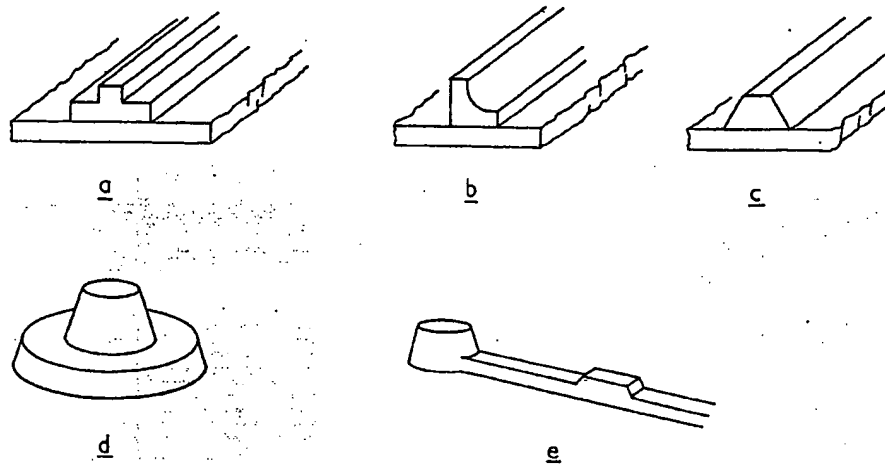


FIG. 4

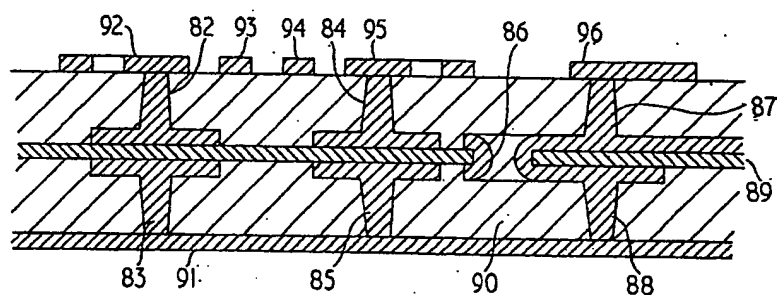
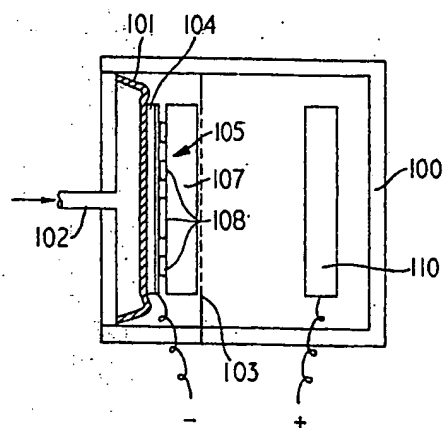


FIG. 5

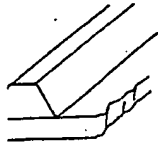


1,098,182 COMPLETE SPECIFICATION

4 SHEETS

This drawing is a reproduction of the Original on a reduced scale.

SHEETS 3 & 4



ε

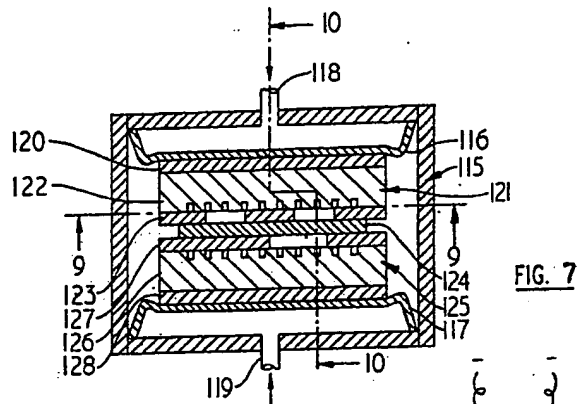
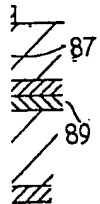


FIG. 7

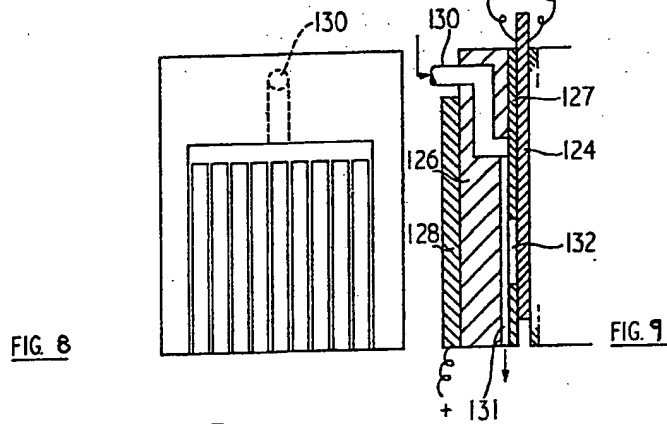


FIG. 8

FIG. 9

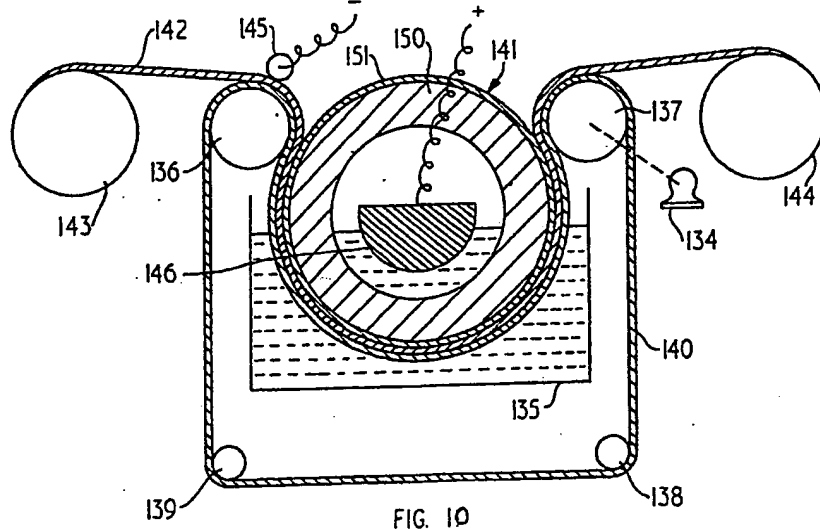


FIG. 10

1,098,182 COMPLETE SPECIFICATION
4 SHEETS
This drawing is a reproduction of
the Original on a reduced scale.
SHEETS 3 & 4

